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Description

This invention concerns an endotract antenna device for hyperthermia and, more specifically, it reletes to an endotract antenne device heving a microweve radiation entenne to be used in the hyperthermia therepy of tumors or the like on the organs inside the body.

In hyperthermia therapy for carcinoma, which utilizes the property of tha cancer cells that they ere less resistant than normal cells egainst heat or elevated temperature, a microwave radietion antenna is used to warm the lesion for the therapy. Such an antenna device is shown in GB—A—2 045 620 to have an antenna in a surrounding polymer element. It is said that liquid cooling may be applied to the metal shaft of the device.

It is desired thet tha radiation antenna is as thin as possibla so that it may be inserted deeply into the endotract of the body for the therapy of organs insida the body, for example, a digastive organ, and a sort of linaer dipola antenna has been employed so far for such a purpose.

However, since the conventional dipole entanna is designed with consideration of the dimensionel stebility, and lacks flexibility, it is difficult to disposa the convantional linear dipole antenna in direct contact with a surface of the organ at the lesion, and there is fear that gases or fluid may ramain in the gap betwean tha antenna and tha surfaca of the organ.

As a rasult, tha electromegnetic energy emitted from tha microweva antenne of such an endotract antenna davica is absorbed by the body fluid in the gap, or reflected at tha gap, and cannot always serva for effectiva and uniform warming of the lesion and for affactive hyparthermia tharapy of the lesion.

Furthar, since tha conventional dipola antanne comprisas a pair of elactrodes differant from each othar in shapa, it is difficult to pradatarmine tha field pattarn of alactromagnatic enargy emitted therefrom and, accordingly, to adequataly situete the antenna ralative to the lesion aree.

According to the presant invention, there is provided en endotract antenna device for hyperthermia comprising an entenne for radiating microwavas, and an envalope made of a polymer meterial surrounding said antenna, cherecterised in that the envelope is a balloon-like member made of a flexible and elastic polymeric thin film and forming a chamber of variable voluma, and by meens for feeding and draining a cooling liquid to end from the inside of said belloon-like mamber.

Preferably, the microwave radiating antenna comprises two elongeted and identically-shaped conductors erranged on a streight line end slightly spaced apert from eech other, eech having a length equal to an integral multiple of about 1/4 of a wavelength of the microwaves to be emittad from said antenna.

In preferred embodimants, tha microwave radiation entenne comprises e pair of flexible tubuler members mede of electrically conductive material for microwave radiation mounted to the outer circumferance of a rod-like member made of a flexible and insulating material.

The invention allows provision of an endotract entenne device capable of closely contacting and effectively warming the lesion at the wall of the tract or lumen while avoiding localized overheating. The microwave antenna can be situated surely at a desired position in the tract or lumen, and is highly flexible and effectively applicable to the hyparthermia therapy for the lesion in the tract or lumen.

In order that the invention mey be more clearly understood, the following description is given, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is an explanatory view of an andotract antenna device for hyperthermia as a preferred embodimant of this invention;

Figure 2 is an axplanatory sectional view of e prefarred ambodiment of a microwave antenna contained in the endotract antenna device for hypertharmia;

Figure 3 is an axplanatory viaw of tha radiation pattarn of tha antenna shown in Figure 2; and

Figures 4 and 5 are axplanatory viaws respectivaly for modified preferred embodiments of the microweve entenna conteined in tha endotract antanna davice for hyparthermia.

Referring to Fig. 1, an andotract antenne davice for hypertharmia 1 comprises a coaxial cable 6 for the microwave transmission connected at one end 2 to a microwava oscillator or generator 3 which cen continuously ganaratas microwaves at a frequancy betwean 300—3,000 MHz, for axampla, 915 MHz and formad et the othar end 4 with a sort of linear dipole antenna 5, a balloon 8 mada of a flaxible and alastic polymeric thin film and forming e chambar 7 of a variabla voluma which surrounds the microwave radietion antanna 5 and recalves purifiad watar for cooling, a feed tube 11 opaned at one end 9 thereof to tha water-containing chamber 7 and communicated at the othar end 9e thereof with a feed pump 10 so as to feed the purified water into tha chamber 7, and a draining tube 15 connactad at ona end 12 tharaof to tha balloon 8 and opened at the other end 13 thereof by way of a throttling device 14 for tha water pressure control so as to drain the water from the beiloon 8. In the drawing, the pump 10, the feed tube 11, the throttling device 14 and the draining tube 15 constitute maens for feeding and draining the cooling water.

The fraquency of the microwaves generated from the oscillator 3 to be applied to tumors at the well of the trect is usually in the order of between 300—3000 MHz (wave length (λ) is in the order of 10—1 cm in the body fluid or at tha lesion). The frequency of the microwaves may be selected from e plurality of oscillation frequencies that can be generated from the oscillator 3 depending on the size of tha antenna 5. The output power of the oscillator 3 may be in the order of 10 to 200 wett for example.

The antenna 5 comprises tubular conductors 16 and 17 each of the identical shape and separated from each other by an insulator 19. Instead of providing the tubular conductor 16, the top end of the central conductor may be exposed about by the length of λ/4.

The antenna 5 having the electrodes of identical shapes and the coaxial cable 6 will be explained in detail hereinafter referring to the embodiments shown in Figs. 2 to 5.

The balloon 8 is secured at its base portion to the and 12 of the water-drein tube 15 and secured about at the center of its top end 18 to the top end of the microwave antenna 5.

It is preferred that the polymeric film of the balloon 8 is made of highly flexible material so that the film can be in close contact with the surface of the endotract at the lesion and that the film is made as thin as possible so that it may absorb less energy of the microwaves emitted or transmitted from the antenna 5, provided that the film has an elasticity sufficient to contain water therein under a certain pressure. In the case of using a thin rubber film for the balloon 8, the film thickness is, for instance, less than 0.5 mm (energy loss of about 30%) and, preferably, less than 0.1 mm (energy loss of about 10—15%). Although the balloon 8 in the illustrated embodiment is shaped such that it is expandable through an oval or elliptic shape to a generally spheric shape, it may take any other configuration. For instance, the balloon 8 may be protruded longitudinally at the top end 18 and, in this case, the top end of the antenna 5 may be inserted into but not fixed to the alongated recess of the top end 18. The film material for the balloon 8 is preferably rubbary polymer material, for example, netural rubber of synthetic rubber such as silicone rubber.

In order to trensmit the microwaves emitted from the antenna 5 as effectively as possible to the lesion, the cooling medium flowing the inside of the balloon 8, preferably, comprises liquid medium at least mainly composed of water so thet the emitted microwaves ere transmitted therein substantially at the same wevelength es in the lesion. Purified weter with less transmission loss such as absorption is more preferred.

The purified water as the cooling liquid flowing inside of the balloon 8 is kept at en appropriate temperature of ebout 0—45°C and, preferably, about 15—42°C so that the temperature at the lesion can be maintained at 42—45°C by the purified water in co-operetion with the antenna 5.

Further, the flow rate of the cooling water is controlled by the throttling device 14. The throttling device 14 comprises a manually- or automatically-controlled valve, the opening degree of which can be edjustad continuously. The throttling device or valve 14 also serves to produce an adequate pressure within the belloon 8 so es to expand the balloon 8 into en intimete contact with the wall of the tract or lumen orgen.

In tha illustreted embodiment, the drain tube 15 is constituted as e davice main body which is to be insertad through the tract or lumen end through which the coaxial cable 6 and the feed tube 11 are extended. Alternatively, the feed tube 11 may be modified to be constituted as the device main body while extending the drain tube 15 and the coaxial cable 6 the inside of the feed tube 11. In this modified embodimant, the bese portion of the balloon 8 is secured to the end of the water-feed tube 11. Furthermore, the feed tube 11, the drain tube 15 and the coaxial cable 6 may be bundled in close contact togethar at their raspactive outer circumferential surfaces so that the three members form an elongated antenna device main body as a whole, with tha balloon 8 being capped over the open ends of the tubes 11, 15 so as to surround the antenna 5, in the case where the assembly can be formed so smooth and thin as can be intaken, for example, from the mouth into the stomach.

The purified water may be used recyclically by connecting the drain tube 15 to the pump 10 by wey of a reservoir not shown. Rafarence numeral 20 in the draining denotes sealed portions to prevent the leak of the water.

A thermosensor or temperature detector 21 is fixed to the outer surface of the central portion of the circumferential wall of the balloon 8 to detect the temperature at the film or membrane surface of the balloon 8, that is, the temperature at the inner surface of the wall of the tract organ. The thermosensor 21 may be a thermocouple or thermistor. The lead 22 for the thermosensor 21 is disposed along the outer surface of the drain tube 15 constituting the device main body in the illustreted embodiment, it may, however, be passed through the inside of the drain tube 15 as the device main body if desired. The average output from the oscillator 3 and the temperature of the cooling water fed to the balloon 8 ere controlled depending on the output signal from the thermosensor 21, that is, on the temperature detected by the sensor 21 so that the temperature of the lesion may be kept at about 42—45°C. The temperature control mey be carried out automatically by e suitable control means.

In the endotract antenne device for hyperthermia 1 constituted as described abova, since the microwave rediation antenna 5 is disposed to the inside of the belloon 8 through which the cooling liquid passes, the balloon 8 can be deformed just corresponding to the uneven inner profile of the wall of the tract organ and put to an intimate fitting with the inner surface of the wall, that is, the surface of the lesion by the control of the flow rate and/or the pressure of the cooling liquid flowing inside of the balloon 8, whereby the microwave emitted from the antenna 5 can be transmitted with little transmission loss to the lesion through the purified water in the chember 7 and the thin film of the balloon 8. Furthermore, control for the tempereture and the flow rate of the cooling water flowing inside of the balloon 8 can ensure the hyperthermia therapy while preventing localized over-heeting and maintaining the temperature of the wide lesion area at a temperature of between 42—45°C.

As described above, according to this invention,

since the endotract antenna device for hyperthermia comprises a microwave radiation antenne, a balloon-like member made of a polymer thin film and surrounding the antenna, and means for feeding and draining a cooling liquid to and from the inside of the balloon-member, the energy of the microwaves emitted from the antenna can be effectively and uniformly given to the lesion in the tract or lumen organ, thereby enabling to warm the lesion effectively.

Fig. 2 shows an embodiment of the microwave antenna contained in the endotract antenna device for hyperthermia. In the Figure 2, the coaxial cable 6 for the microwave transmission comprises e central or inner conductor 31, an insulator 32, an outer conductor 33 and e protection cover 34. The cable 6 is connected at one end thereof to the microwave oscillator or generator 3 capable of continuously generating microwaves at a frequency, for example, of 915 MHz.

The coaxial cable 6 is preferably designed, for enabling effective transmission of the microwaves and easy insertion into the tract where the lesion is located, such that the cable has an outer diameter of about 2—10 mm and comprises the central conductor 31 in the form a single wire or twisted wires mede of silver-plated copper wire, the insulator 32 mede of a polymer material with less dielectric loss and the outer shielding conductor 33 in the form of a breided tube or helically wound braided cable made of silver-plated annealed copper wires. Further, the protection cover 34 for the cable is, preferably, made of such a polymer material as exhibiting no toxicity when put to be in contact with the tract, for example, fluoro resin, polyvinyl chloride and polyethylene.

The antenna 5 for microweve transmission or radietion is formed at the top end side 36 of the coaxial cable 6 by removing the protactive cover 34 at its top end side 36. The antenna 5 comprises the tubular conductor 17 of about λ/4 in length (λ is a wave length of the microwave in the chamber 7 in Fig. 1) integrally formed with the outer conductor 33, and another tubular conductor 16, of tha same shape as the tubular conductor 17, which is electrically connected at its top end 39 by means of a soldered portion 39a to the central conductor 31 end attached to the insulator 32 with a slight axial gap 41 from en extended end 40 of the tubular conductor 17. The length for each of the tubular conductors 17 and 16 may be an integral multiple more than one, that is, 2, 3, 4, ... times of the length λ/4.

The antenna 5 may be fabricated, for instance, by the following procedures. At first the central conductor 31 is exposed to about 1 mm et the top end 39 of the coaxial cable 6 (having en outer diameter, e.g., of 3 mm) and the protective cover 34 is removed by the length of ebout λ/2 (e.g., about 22 mm for the case of 915 MHz) at the top end 36 to reveel or expose the outer conductor 33 composed of the braided tubes. Then, the exposed portion of the conductor 33 about λ/2 in length is entirely impregnated with e solder to form a tubular body uniformly deposited or coated with the solder over the exposed portion. Thereafter the tubular body is divided into two exposed tubular conductors 16 and 17 each of a same length by forming a circular slit at a position of ebout λ/4 (for example, of ebout 11 mm) from the top end of the tubular body. Then, the tubular conductor 16 at the top end side 39 is drawn by about 1 mm toward the top end 39 and electrically connected by means of soldering with the projected end 31a of the central conductor 31.

The central conductor 31 and the tubular conductor 19 on the side of the top end 39 may be electrically connected not only by way of soldering but also with an annular conductor plate made of copper or the like. The tubular conductor 16 mey be formed by fitting a tubular conductor of about λ/4 in length made of copper or like other metal over the insulator 32, instead of using the braided tubes impregnated with the solder. Furthermore, the tubular conductor may have an end wall formed with an aperture through which central conductor 31 is fitted. In addition, the other tubuler conductor 17 may also be formed with e copper tube or the like, which is fitted over the insulator 32, electrically connected with the outer conductor 33 and secured to the coaxial cable 6.

At first, the braided portion for forming the tubular conductor 17 may be exposed to more than λ/4 in length and impregnated with soldar or the like to form an exposed tubular conductor of more than λ/4 in length. In this case, insulating resin adhesives or the like can be applied for covering a portion of the tubular conductor near the opening end of the protective cover 34 in such a way that the tubular conductor may be exposed over length of about λ/4 and that liquid materials may not intrude between the tubular conductor 17 and the outer cover 34 to the inside of the axial cable 6.

When the antenna 5 was connacted to the microwave oscillator 3 opereting at 915 MHz while metching an impadance as long as possible, the antenne had characteristics of an output power of 15 watt and a reflection factor of 5%. The microwave radiation pattern at 915 MHz from the antenne 5 immersed in a physiological saline water waa as shown in Fig. 3. Fig. 3 shows an isothermal curve at 40°C by the linee 43, which are rotetionally symmetrical about the center line 37a of the antenne 5 and are also symmetrical for the mirror operation or reflection in en imaginary plene passing through the gap 41 in perpendicular to the line 37a. The line 43 exhibits peaks 43a et portions facing to the gap 41. Accordingly, effective therepy can be carried out by disposing the antenna 5 so as to oppose the paak 43a, thet is, the gap 41 to the lesion, because the microweve antenne 5 is formed vertically symmetrical with respect to the gap 41 and because the electric power is fed to the tubular conductors 16 and 17 of the antenna 5 from the separated side ends 44 and 45 respectively.

Instead of forming the microwave antenna directly on the extension of the intermediate

insulator 32 for the coaxial ceble 6 as shown In Fig. 2, a microwave antenna 59 may be modified as shown in Fig. 4, In which a cylindrical insulating resin tube 50 of about λ/2 in length is fitted over the extension 32a of the Insulator 32 slightly longer than λ/2 in length and cylindrical metal tubular conductors 51, 52 made of copper and the like of about λ/4 in length, respectively, are fitted while separated from each other by a gap 53 over the resin tube 50. A centrel conductor 31 of a coaxial cable 6 is electrically connected by means of soldering or the like to the top end 54 of the tubular conductor 51 remote from the tubular conductor 52 by way of a disc 56 made of copper or like other metal and formed with an aperture 55. The outer conductor 33 is electrically connected by means of soldering or the like to the end 57 of the tubular conductor 52 remote from the tubular conductor 51 by way of conductor wlres 58. The conductor wlres 58 may be formed by partially releasing and spreading the bralded tube of the outer conductor 33. The characterlstics and the rediation pattern of the antenna 59 were the same as those of the antenna 5.

As described above, since the microwave antenne contained within the balloon of the endotrect antenna device for hyperthermie according to thls invention comprises two Identicelly-shape elongated conductors of ebout λ/4 in length formed et the top end of e coexiel ceble on e strelght line end sllghtly speced epert from each other, the radiatlon energy Is mede at the maxlmum near the separated portlon or gap between the two conductors and the effectlve therepy can be carrled out by opposing the separated portion to the lesion.

Fig. 5 shows another modifled embodiment of the microweve entenna according to this invention, in which a flexlble coaxial cable 6 for transmitting mlcrowaves has the same constitution es the coaxial cable shown In Fig. 2 end it is connected et one end thereof to e microwave oscillator 3 capeble of contlnuously genereting mlcrowaves. The central conductor 31 of the coexlal cable is sllghtly projected at the top end 67 thereof.

A flexible tube 68 mede of flexible polymer materlal such es soft polyvinyl chloride Is supported at Its bese end 68a to the top end of the coaxial cable 6 and the top end of the flexible tube 68 is projected by about λ/4 or more in length from the coaxial cable 6. The tube 68 has a radial penetrating hole 70 et the position of about λ/4 from the top and 69 end another redial penetreting hole 72 et the position of about λ/4 or more from the top end, on the opposlte side to the hole 70 and generally opposed to the top end 71 of the outer conductor 33 of the coexiel ceble 6.

While the flexible tube 68 has a lerger inner dlemeter then the outer dlameter for the coaxlal cable 6 so as to be kept hlghly flexible the Inner diameter of the tube 68 mey be the same as the outer diameter of the coexiel cable 6, provided thet the coexiel ceble 6 can be inserted and that the essembly of the tube 68 end the ceble is kept highly flexible.

The flexible tube 68 may be made of flexible polymer materiel such as rubber and high pressure process polyethylene.

Electrlcally conductive and flexible cyllndrlcal members 73 and 74 are fitted over the flexible tube 68 whlle spaced epert, for example, by ebout 1 mm from each other so that their opposing ends 75 and 76 are situeted at the openings of the holes 70 end 72 respectively. The hollow cylindrical members 73 and 74 are made of bralded tubes made of, for example, copper wires braided in a hollow cylindrical configuration and have about λ/4 in length (for example, 11 mm at 915 MHz) in the condition fitted to the tube 68. The cylindrical members 73 and 74 are secured et both ends 75, 77 and 76, 78 respectively to the tube 68. The cylindrical member 73 is electrically connected at Its one end 75 to the top end 67 of the central conductor 31 by way of a conductor wire or lead 79 passed through the hole 70, while the cylindrical member 74 Is electrically connected at its one end 76 to the top end 71 of the outer conductor 33 by way of a conductor wire or lead 80 passed through the hole 72.

A cap 81 rounded at the top end is mounted to the top end 69 of the flexible tube so as to facllitate the insertion of the flexible microweve antenna 82, into the tract, comprising the flexlble and electrically conductive member 73 of about λ/4 In length connected to the central conductor 31 end the flexible and electrlcally conductlve cylindrical member 74 of ebout λ/4 in length connected to the outer conductor 33. The cap 81 preferably made of flexible polymer meterlel prevents the body fluid from intruding to the Inside of the tube 68 In cooperation wlth the resin adhesives filled In tha holes 70 end 72.

The flexible microweve entenne 82 heving the foregoing constitution may be essembled, for example, by fitting the bralded tubes 74 and 73 over the tube 68 In which the holes 70 end 72 ere formed et predetermined positlons, securing the tube 68 over the top end of the coaxlal cabla 6, connecting the breided tubes 74 and 73 with the outer end the central conductors 33 and 31 by way of the conductor wlres 80 end 79 by means of soldering or the llke, securlng the bralded tubes 74 end 73 to the tube 68 so as to have the predetermined length of λ/4 at the position spaced epert by ebout 1 mm from eech other, further securing the conductor wires 80 end 79 to the holes 72 and 70 respectively end mounting the cap 81 over the tube 68 and the bralded tube 73.

Alternatlvely, the outer conductor 33 may be connectad electrically to the flexible hollow cylindrical member 73 at the top end, whlle the central conductor 31 may be connected electrlcally to the other cylindrical member 74. The position and the number for the penetrating holes 70 and 72 In the tube 68 ere determined in view of the current dlstribution and not restricted to the illustrated positlons generally dlametrically opposing each other.

In e case where It Is desired to constitute a perticularly thin antenna or the lika, a pair of fine or

thin flexible braided tubes 73 and 74 may be directly fitted around the outer circumference of the flexible protective cover 34 of the coaxial cable 6. Furthermore, the tubular braided conductor of the outer conductor 33 may be used directly as a pair of flexible braided tubes 73 and 74.

The flexible microwave antenna 82 having the foregoing constitution can be in close contact with the tract wall at the lesion and deeply inserted into the tract because of its flexibility, and thus can be effectively applied to the therapy of the lesion. In addition, in a case where the antenna 82 of 18 W in output power was deformed or curved by transversely or laterally displacing the top end 83 of the antenne 82 by 10 mm from its straightly extended position, the reflection factor can be maintained not more than 5—7%. This result shows that, although the antenna deformation has been avoided in the prior art fearing the degradation in the antenne characteristic, the flexible antenna 82 according to this invention can be effectively applied to the hyperthermia therapy with less fear of degrading the characteristic.

As described above, according to this invention, since the flexible microwave antenna contained in the endotract heating antenne device comprises flexible cylindrical members made of electrically conductive material mounted to the outer circumference of e rod-like member mede of flexible and insulating material, it can be effectively applied for the therapy of the lesion in the tract or lumen.

The microwave antenna described herein above can be used not only in a condition contained in the endotract antenna device for hyperthermia but also in a condition in direct contect with the body fluid or the lesion.

## Claims

1. An endotract antenna device for hyperthermia comprising an antenne (5) for radiating microwaves, and an envelope (8) made of a polymer material surrounding said antenna (5), characterised in that the envelope (8) is a balloon-like member made of e flexible end elastic polymeric thin film and forming e chamber (7) of variable volume, and by means (11, 15) for feeding and draining a cooling liquid to and from the inside of said balloon-like member (8).

2. An antenna device according to claim 1, characterised in that the microwave radiating antenna comprises two elongated and identically-shaped conductors (17, 16; 51, 52) arranged on e straight line and slightly spaced apart from each other, each having a length equal to en integral multiple of about 1/4 of a wavelength of the microwaves to be emitted from said antenna.

3. An antenna device according to claim 2, characterised in that the two identically-shaped conductors (17, 16; 51, 52) are formed at the top end of a coaxial cable (6), and comprise a tubular conductor of a length of about 1/4 of the wavelength electrically connected to one of a central conductor (31) and an outer conductor (33) of the coaxial cable, and another tubular conductor of a length of about 1/4 of the wavelength electrically connected to the other one of the outer conductor (33) and the central conductor (31) of the coaxial cable (6).

4. An antenna device according to claim 3, characterised in that said two tubular conductors (17, 16) are attached to an insulator (32) between the central conductor (31) and the outer conductor (33).

5. An antenna device according to claim 3, characterised in that the microwave radiation antenna (5) includes e hollow cylindrical insulating resin tube (50) having a length of about 1/2 of the wavelength fitted over en insulator (32) disposed between the central conductor (31) and the outer conductor (33) of the coaxial cable (6), and in that said two tubular conductors (51, 52) forming a gap therebetween fit around the resin tube (50), each of said two tubular conductors (51, 52) being made of e cylindrical metallic tube.

6. An antenne device according to any one of claims 3 to 5, characterised in that the coaxial cable (6) comprises the central conductor (31) which is composed of a single wire or twisted wires made of e silver-plated copper wire, the insulator (32) between the central conductor (31) and the outer conductor (33) and which is made of a polymer material with less dielectric loss, the outer shielding conductor (33) which is composed of e braided tube or e helically wound braided cable made of silver-plated annealed copper wires, and a protective cover (34) which is made of a polymer material and is disposed to the outer side of the outer conductor.

7. An antenna device according to claim 1, characterised in that the microwave radiation antenna comprises e pair of flexible tubular members (73, 74) made of electrically conductive material for microwave radiation mounted on the outer circumference of e rod-like member (68) made of e flexible end insulating material.

8. An antenne device according to claim 7, characterised in thet the rod-like member (68) is hollow end contains an end portion of a coexial cable (6) including a central conductor (31), an outer conductor (33), an insulator (32) between the central conductor and the outer conductor, and a protective cover (34) outside the outer conductor, the coaxial cable (6) being electrically connected to the tubular members (75, 76) and the rod-like member (68) projecting beyond the end portion of the coaxial cable (6).

9. An antenna device according to claim 7 or 8, characterised in that the flexible tubular members (73, 74) are each braided metallic tubes of a length of about 1/4 of the wavelength of the microwaves to be emitted from the antenna and are fitted over the rod-like member (68) slightly spaced apart from each other.

10. An antenna device according to any preceding claim, characterised in that said radiation antenna (5) is connected by way of a coaxial cable (6) to e microwave oscillator (3).

11. An antenna device according to any preceding claim, characterised in that the free end of the radiation antenna (5) is attached to a central portion (18) of a top end of said balloon-like member (8).

12. An antenna device according to any preceding claim, characterised in that the polymeric film is made of rubber.

13. An antenna device according to claim 12, characterised in that the rubber is synthetic rubber.

14. An antenna device according to claim 12, characterised in that the rubber is natural rubber.

15. An antenna device according to any preceding claim, characterised in that said feeding and draining means comprises a feeding tube (11) communicated at one end thereof with said balloon-like member (8) so as to feed cooling liquid to the inside of said balloon-like member and a draining tube (15) communicated at one end thereof with said balloon-like member (8) so as to drain the cooling liquid from said balloon-like member.

16. An antenna device according to claim 15, characterised in that said feeding and draining means further includes a pump (10) connected to another end of the feeding tube (11) so as to supply the cooling liquid by way of the feeding tube (11) to the inside of said balloon-like member (8).

17. An antenna device according to claim 15 or 16 characterised in that said feeding and draining means further comprises a throttling means (14) for controlling the flow rate or pressure of the cooling liquid flowing to the inside of said balloon-like member (8).

18. An antenna device according to claim 17 characterised in that the throttling means (14) is disposed at another end of the draining tube (15).

19. An antenna device according to claim 15, 16, 17 or 18 characterised in that the balloon-like member (8) is liquid-tightly attached to the one end of the draining tube (15) the feeding tube (11) is inserted into the draining tube (15) through a side thereof at the other end, and a transmission line (6) for connecting a microwave oscillator (3) with said radiation antenna (5) is inserted in the draining tube (15).

20. An antenna device according to claim 15, 16, 17 or 18 characterised in that the balloon-like member (8) is liquid-tightly attached to the one end of the feeding tube (11) the draining tube (15) is inserted in the feeding tube (11) through a side thereof at the other end, and a transmission line (6) for connecting a microwave oscillator (3) with said radiation antenna (5) is inserted in the feeding tube (11).

21. An antenna device according to any of claims 15 to 20 characterised in that said feeding and draining means comprises means for controlling the temperature of the cooling liquid to be supplied by way of the feeding tube (11) to said balloon-like member (7).

22. An antenna device according to any preceding claim characterised in that the cooling liquid is water.

23. An antenna device according to claim 22 characterised in that the water is purified water.

24. An antenna device according to any preceding claim, characterised by a thermosensor (21) being disposed on the surface of the balloon-like member.

**Patentansprüche**

1. Antennenvorrichtung zur inneren Hyperthermiebehandlung von Körperorganen, die eine Antenne (5) zur Abstrahlung von Mikrowellen und eine diese Antenne (5) umgebende Umhüllung (8) aus einem Polymermaterial enthält, dadurch gekennzeichnet, daß die Umhüllung (8) ein ballonartiges Element aus einem flexiblen und elastischen, dünnen Polymerfilm ist und eine Kammer (7) von veränderlichen Volumen bildet, und daß die Vorrichtung Mittel (11, 15) für die Zuführung und Ableitung einer Kühlflüssigkeit zu und aus dem Inneren dieses ballonartigen Elements (8) aufweist.

2. Antennenvorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Mikrowellen abstrahlende Antenne zwei längliche und identisch gestaltete Leiter (17, 16; 51, 52) enthält, die auf einer geraden Linie angeordnet und geringfügig voneinander beabstandet sind, wobei die Länge eines jeden Leiters ein ganzzahliges Vielfaches von etwa 1/4 der Wellenlänge der von dieser Antenne auszusendenden Mikrowellen beträgt.

3. Antennenvorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß die zwei identisch geformten Leiter (17, 16; 51, 52) an dem Ende eines Koaxialkabels (6) ausgebildet sind und daß sie bestehen aus einem Hohlleiter mit einer Länge von etwa 1/4 der Wellenlänge, welcher elektrisch leitend verbunden ist mit dem zentralen Leiter (31) oder mit dem Außenleiter (33) des Koaxialkabels, sowie aus einem weiteren Hohlleiter mit einer Länge von etwa 1/4 der Wellenlänge, welcher elektrisch leitend verbunden ist mit dem Außenleiter (33) oder dem zentralen Leiter (31) des Koaxialkabels (6).

4. Antennenvorrichtung nach Anspruch 3, dadurch gekennzeichnet, daß diese beiden Hohlleiter (17, 16) an einem zwischen dem zentralen Leiter (31) und dem Außenleiter (33) liegenden Isolator (32) befestigt sind.

5. Antennenvorrichtung nach Anspruch 3, dadurch gekennzeichnet, daß die Mikrowellen-Antenne (5) eine hohle zylindrische, isolierende Röhre (50) aus Kunstharz einschließt, die eine Länge von etwa 1/2 der Wellenlänge besitzt und die über einen, zwischen dem zentralen Leiter (31) und dem Außenleiter (33) des Koaxialkabels (6) angeordneten Isolator (32) geschoben ist, und daß diese beiden Hohlleiter (51, 52), die zwischen sich einen Spalt bilden, um die Harzröhre (50) passend angeordnet sind, wobei jeder dieser beiden Hohlleiter (51, 52) aus einem zylindrischen Metallrohr hergestellt ist.

6. Antennenvorrichtung nach einem der Ansprüche 3 bis 5, dadurch gekennzeichnet, daß das Koaxialkabel (6) besteht aus:

dem zentralen Leiter (31), der aus einem einzelnen Draht oder aus verdrillten Drähten aus versilbartem Kupferdraht besteht,

dem Isolator (32), der zwischen dem zentralen Leiter (31) und dem Außenleiter (33) angeordnet ist und aus einem Polymermaterial mit geringeren dielektrischen Verlusten hergestallt ist,

dem äußeren, abschirmenden Leiter (33), der aus einem Matallschleuch oder einem spiralig umwickelten Kabel aus versilberten, geglühten Kupferdrähten besteht,

sowie aus einem Schutzüberzug (34), dar aus einem polymeren Material hargestellt und auf die Außenseita des Außenleiters aufgebracht Ist.

7. Antannenvorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Mikrowellan-Antenne ein Paar flexibler rohrförmiger Elemente (73, 74) aus elektrisch laitendam Material zur Mikrowellanabstrahlung enthält, die auf dem äußeren Umfang elnes aus flexiblem und isolierendem Material hargestellten, stabförmlgen Elements (68) angeordnet sind.

8. Antennanvorrichtung nach Anspruch 7, dadurch gekennzaichnet, daß des stabförmiga Elamant (68) hohl ist und einen Endabschnitt eines Koaxielkabels (6) enthält, zu dem ain zentreler Leiter (31), eln äußerar Laitar (33), ain Isolator (32) zwischen dem zentralan Leitar und dem äußeren Lelter und ain Schutzübarzug (34) auf dar Außanseite des äußeren Leitars gahören, wobel das Koaxialkabel (6) elaktrisch leitand mit den rohrförmigen Elamanten (75, 76) varbundan ist und des stabförmige Elamant (68) übar dan Endabschnitt des Koaxialkabels (6) hlneusragt.

9. Antennenvorrichtung nach Anspruch 7 oder 8, dadurch gakanzeichnet, daß die flaxiblan rohrförmlgen Elemente (73, 74) baide Matallschläucha mit alnar Länga von etwa 1/4 dar Wellanlänge dar von dar Antanne auszusandanden Mikrowellan sind und daß sia in geringem Abstand voneinandar passand übar dem stabförmlgen Element (68) engeordnet sind.

10. Antennenvorrlchtung nach elnem der vorstahanden Ansprücha, dadurch gekennzaichnet, daß diasa Abstrehlungs-antenne (5) übar ein Koaxialkabel (6) an einen Mikrowellen-Oszillator (3) angeschlossen Ist.

11. Antennenvorrichtung nach elnem der vorangegangenen Ansprüche, dadurch gekannzeichnet, daß das fraie Ende der Abstrahlungsentenne (5) an einem zentralen Abschnltt (18) aines Scheitals diesas ballonartigen Elaments (8) befestlgt Ist.

12. Antennenvorrichtung nach ainem der vorangegangenen Ansprüche, dadurch gekennzeichnet, daß der Polymerfilm aus Gummi bastaht.

13. Antennenvorrichtung nach Anspruch 12, dadurch gekennzaichnet, deß der Gummi synthetischer Gummi ist.

14. Antennenvorrlchtung nach Anspruch 12, dadurch gekennzeichnet, daß der Gummi Naturgumml ist.

15. Antennenvorrlchtung nech einem der vorangegangenen Ansprüche, dadurch gekennzeichnet, daß diese Mittel zur Zuleitung und Ableitung aus einer Zuieitung (11), deren eines Ende mit diesem ballonartigen Element (8) verbunden Ist, um Kühlflüsslgkait dem Inneren diases bellonartigen Elements zuzuführen, und aus einer Ableitung (15) bestehen, deren eines Ende mit diesem ballonartigan Elemant (8) varbundan ist, um die Kühlflüssigkeit aus dlesem ballonartigen Element abzuziehen.

16. Antennenvorrichtung nach Anspruch 15, dadurch gakannzaichnet, daß zu diesen Mitteln zur Zuleitung und Ableitung ferner elne Pumpe (10) gehört, dle an das andere Ende der Zuleitung (11) angeschlossen ist, um die Kühlflüssigkeit über die Zuleitung (11) ins Innere dieses bellonartigen Eiements (8) zu fördern.

17. Antennenvorrichtung nach Anspruch 15 oder 16, dadurch gekennzaichnat, daß diese Mittel zur Zuleitung und Ableitung außerdem eina Drossel (14) zur Regullarung der Flließgeschwindlgkalt oder des Drucks dar durch das Innere dieses ballonartigen Elements (8) fließenden Kühlflüsslgkait enthält.

18. Antennanvorrichtung nach Anspruch 17, dedurch gekennzaichnat, daß dle Drossal (14) an elnem anderen Ende der Ableitung (15) angebracht Ist.

19. Antennanvorrlchtung nach Anspruch 15, 16, 17 oder 18, dadurch gekannzalchnet, daß das ballonertige Elemant (8) flüssigkeitsdicht an dem alnen Ende der Ableitung (15) bafastigt ist, dia Zuleitung (11) In dia Ablaltung (15) an daren endarem Enda seitlich eingeführt ist und eine Übertregungslaitung (6) zur Varbindung eines Mikrowallan-Oszillators (3) mit diasar Abstrahlungsantanna (5) In die Ablaitung (15) aingeführt Ist.

20. Antennenvorrlchtung nech Anspruch 15, 16, 17 oder 18, dedurch gekennzelchnat, daß des bellonartige Elamant (8) flüssigkeitsdicht an dam elnen Ende dar Zuleitung (11) bafastlgt ist, dia Ableltung (15) in dia Zulaitung (11) en daren andaram Enda seltlich elngeführt ist und elna Übartregungsleltung (6) zur Verbindung einas Mikrowellen-Oszillators (3) mit dieser Abstrahlungsantanna (5) in die Zuleitung (11) alngaführt ist.

21. Antennenvorrichtung nach einem der Ansprüche 15 bis 20, dadurch gekannzeichnat, daß diese Mittal zur Zuleitung und Ableltung Mittel zur Regulierung der Temperatur der über die Zuleitung (11) zu diasam ballonartigan Elemant (8) zu fördernden Kühlflüssigkait aufwaisen.

22. Antennenvorrichtung nach einem der vorangegengenen Ansprüche, dadurch gekennzeichnet, daß die Kühlflüssigkeit Wesser ist.

23. Antennenvorrichtung nach Anspruch 22, dadurch gekennzelchnet, daß das Wasser gereinigt Ist.

24. Antennenvorrichtung nach einem der vorengegengenen Ansprüche, dadurch gekennzeichnet, daß eln Thermofühler (21) auf der Oberfläche des ballonertigen Elaments angeordnat ist.

Revendications

1. Un dispositif d'antenne endotract pour hyperthermie, comprenant une antenne (5) pour la radiation de micro-ondes et une enveloppe (8) en matérieu polymère entourant la dite antenne (5), le dispositif étant caractérisé en ce que l'enveloppe (8) est un élément de type ballon réalisé è partir d'un mince film polymère flexible et élastique formant une chambre (7) de volume variable, des moyens (11, 15) étant prévus pour elimenter un liquide de refroidissement à l'intérieur du dit élément de type ballon (8) et pour évacuer ce liquide de l'intérieur de cet élément.

2. Un dispositif d'antenne selon la revendication 1, caractérisé en ce que l'entenne pour la radiation da micro-ondes comprend deux conducteurs allongés et profilés de manière identique (17, 16; 51, 52) disposés en ligne droite et légèrement distents l'un de l'autre, checun de ces conducteurs ayant una longueur égale à un multiple intégral d'environ 1/4 d'une longueur d'onde des micro-ondes devant être émises à partir de la dite antenne.

3. Un dispositif d'antenne selon la revendication 2, carectérisé en ce que les deux conducteurs profilés de manière identique (17, 16; 51, 52) sont formés à l'extrémité supérieure d'un câbla coaxial, (6), et comprennent un conducteur tubulaire d'une longueur d'environ 1/4 de la longueur d'onde, raccordé électriquement à un des conducteurs centraux (31) et à un des conducteurs extérieurs (33) du câble coaxial, et un autre conducteur tubulaire d'une longueur d'environ 1/4 de le longueur d'onde, raccordé électriquement à l'eutre des conducteurs éxtérleurs (33) et à l'autre des conducteurs centraux (31) du câble coaxial (6).

4. Un dispositif d'antenne selon la revendication 3, caractérisé en ce que les deux dits conducteurs tubuleires (17, 16) sont fixés à un isolataur (32) entre le conducteur central (31) et le conducteur extérieur (33).

5. Un dispositif d'antenne selon la revendication 3, carectérisé en ce que l'antenne de radiation de micro-ondes (5) inclue un tube résine isolant cylindrique creux ayant une longueur d'environ 1/2 de la longueur d'onde, monté sur un isoleteur (32) disposé entre le conducteur central (31) et le conducteur extérieur (33) du câble coaxial (5), les deux dits conducteurs tubulaires (51, 52) formant dens cet espece entre le conducteur central (31) et le conducteur extérieur (33) un entrefer prévu pour entourer le tube résine (50), chacun des deux dits conducteurs tubulaires (51, 52) consistant en un tube métallique cylindrique.

6. Un dispositif d'antenne selon une quelconque des revendicetions 3 à 5, caractérisé en ce que le câble coaxial (6) comprend le conducteur centrel (31) qui est composé d'un fil unique ou de fils retordus consistent en fil cuivre plequé argent, l'isolateur (32) entre le conducteur centrel (31) et le conducteur extérieur (33) étant réalisé à partir de matériau polymère avec perte diélectrique réduita, le conducteur de blindage extérieur (33) étant composé d'un tube tressé ou d'un câble tressé enroulé hélicoïdalement consistant en fils de cuivre recuit trempé plaqué argent, et une gaîne protectrice (34) étent réalisée à partir de metérieu polymère et disposée sur le côté extérieur du conducteur extérieur.

7. Un dispositif d'antenne selon la revendication 1, carectérisé en ce que l'antenne de radiation de micro-ondes comprend une paire d'élémants tubulaires flexibles (73, 74) en matériau électriquement conducteur pour la rediation des micro-ondes, ces éléments étant montés sur la circonférence extérieure d'un élément en forme de tige (68) réalisé à partir d'un matériau souple et isolant.

8. Un dispositif d'antenne selon la revendication 7, l'élément en forme de tige (68) est creux et contient une partie d'extrémité d'un câble coaxial (6) incluant: un conducteur central (31); un conducteur extérieur (33); un isolateur (32) antre le conducteur centrel et le conducteur extériaur; et une gaîne protectrice (34) à l'extérieur du conducteur extérieur, le câble coaxial (6) étant raccordé électriquement aux éléments tubulaires (75, 76) et l'élément en forme de tige (68) dépassant au-delà de la partie d'extrémité du câble coaxial (6).

9. Un dispositif d'antenna selon la revendication 7 ou 8, caractérisé en ce que les élémants tubuleires flexibles (73, 74) sont chacun des tubes métalliques tressés d'une longueur d'environ 1/4 de le longueur d'onde des ondes devent être émises à partir de l'entenne et sont montés légèrement distants l'un de l'eutre sur l'élément en forme de tige (68).

10. Un dispositif d'antenne selon une quelconque des revendications précédentes, caractérisé en ce que la dite antenne à radiations (5) est raccordée au moyen d'un câble coaxial (6) à un oscillateur à micro-ondes (3).

11. Un dispositif d'antenne selon une quelconque des revendicetions précédentes, caractérisé en ce que l'extrémité libre de l'antenna à radiations (5) ast fixée à une partie centrale (18) d'une extrémité supérieure du dit élément en forme de ballon (8).

12. Un dispositif d'antenne selon une quelconque des revendications précédentes, caractérisé en ce que le film polymère est en caoutchouc.

13. Un dispositif d'antenne selon la ravendication 12, caractérisé en ce que le caoutchouc ast du caoutchouc synthétique.

14. Un dispositif d'entenne selon la revendication 12, caractérisé en ce que le ceoutchouc est du ceoutchouc neturel.

15. Un dispositif d'antenne selon une quelconque des revendicetions précédentes, caractérisé en ce que le dit moyen d'elimentetion et d'évacuation comprend un tuyau d'alimentetion (11) communiquant à une de ses extrémités avec le dit élément en forme de ballon (8) de manière à alimenter le liquide de refroidissement à l'intérieur du dit élément en forme da ballon, et un tuyau d'évacuation (15) communiquant à une de ses extrémités avec le dit élément en forme de

ballon (8) de manière à évacuer le liquide de refroidissement à partir du dit élément en forme de ballon.

16. Un dispositif d'antenne selon la revendication 15, caractérisé en ce que le dit moyen d'alimentation et d'évacuation inclue en outre une pompe (10) reliée à une autre extrémité du tube d'alimentation (11) de manière à fournir, par l'intermédiaire du tube d'allmentation (11), le liquide de refroidissement à l'intérieur du dit élément en forme de ballon (8).

17. Un dispositif d'antenne selon la revendication 15 ou 16, caractérisé en ce que le dit moyen d'alimentetion et d'évacuation comprend en outre un système d'étranglement (14) pour contrôler le régima de débit ou la pression du liquide de refroidissement s'écoulant à l'intérieur du dit élémant en forme de ballon (8).

18. Un dispositif d'antenne selon la revendication 17, caractérisé en ce que le système d'étranglement (14) est disposé à une autre extrémité du tube d'evacuation (15).

19. Un dispositif d'antenne selon la revendication 15, 16, 17 ou 18, caractérisé en ce que l'élément en forme de ballon (8) est fixé étanche au liquide à une des extrémités du tube d'évacuetion (15), le tube d'elimentation (11) étant inséré dans le tube d'évacuation (15) per un côté de celui-ci à l'autre extrémité, et une ligne de transmission (6) pour le raccordement d'un oscillateur micro-onde (3) à la dite antenne de radietion (5) étant insérée dens le tube d'évacuation (15).

20. Un dispositif d'antenne selon la revendication 15, 16, 17 ou 18, caractérisé en ce que l'élément en forme de balion (8) est fixé étanche au liquide à une des extrémités du tube d'alimentation (11), le tube d'évacuation (15) étant insère dans le tube d'elimentation (11) par un côté de celui-ci à l'autre extrémité, et une ligne de transmission (6) pour le raccordement d'un oscillateur micro-onde (3) à le dite antenne de radiation (5) étant insérée dans le tube d'alimantation (11).

21. Un dispositif d'antenne selon une quelconque des revendications 15 à 20, caractérisé en ce que le dit moyen d'alimentation et d'évacuation comprend un système pour contrôler la température du liquide de refroidissement devant être fourni par l'intermédiaire du tube d'alimentation (11) au dit élément en forme de ballon (7).

22. Un dispositif d'antenne selon une quelconque des revendicetions précédentes, caractérisé en ce que le liquide de refroidissement est de l'eau.

23. Un dispositif d'antenne selon le revendication 22, caractérisé en ce que l'eau est de l'eau épurée.

24. Un dispositif d'antenne selon une quelconque des revendications précédentes, caractérisé par un thermocapteur (21) disposé sur le surfece de l'élément en forme de ballon.

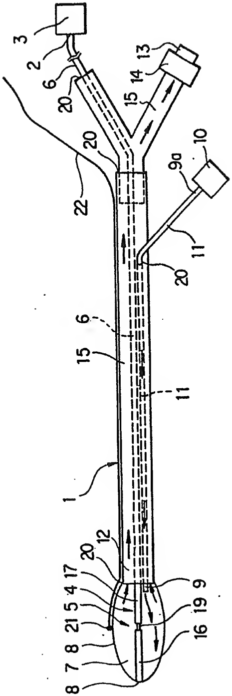


Fig. 1

Fig. 2

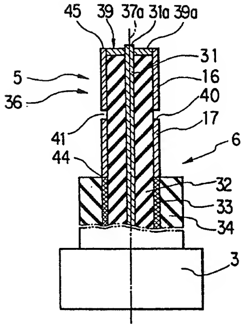
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Fig. 3

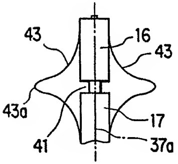
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Fig. 4

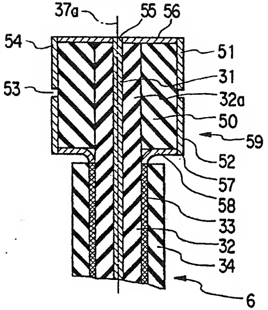
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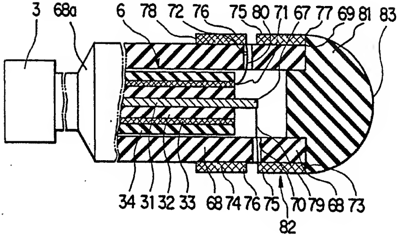
Fig. 5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